LOI Planning:
Tracker and Vertex Detector Designs

Bill Cooper

Fermilab

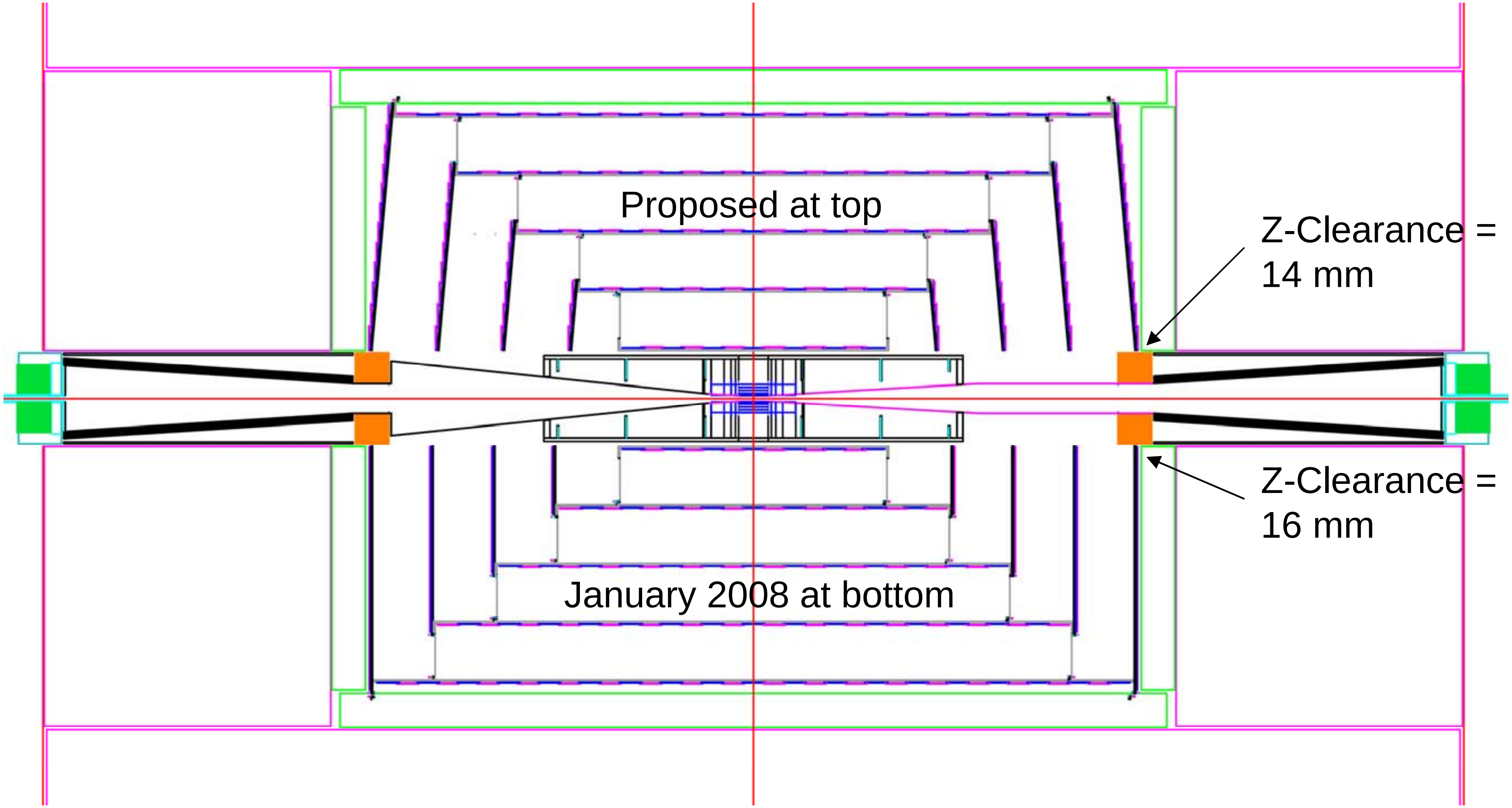
- Talks have been rearranged slightly.
  - – I will describe the overall tracker and vertex detector geometry.
  - – Ron Lipton will describe sensors, sensor R&D, and information to be included in the LOI.

LOI Outer Tracker Geometry

- We have developed an improved understanding of the way sensors might be arrayed on the outer tracker disks.
  - Sensor surfaces would be normal to the beam line.
  - Sensors would be arrayed on the surfaces of “conical” support disks.
  - Stereo would be provided by mating single-sided sensors back-to-back.
  - Stereo angle tentatively = 12^{o}.
- To accommodate the cones, the number of sensor locations in z would be reduced by two in barrels 2, 3, 4, 5.
  - Barrel 1 remains unchanged.
  - R-Phi arrangement of barrel sensors remains unchanged.

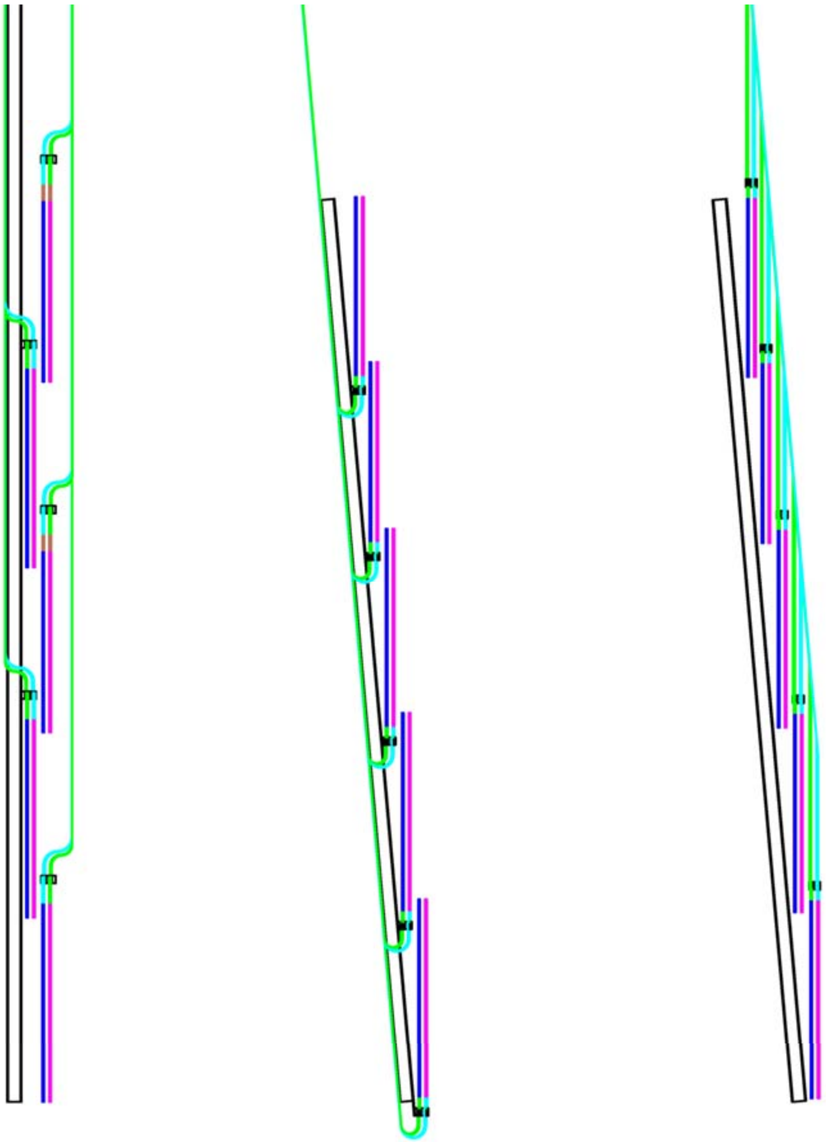
Outer Tracker Geometry

- Conical disks are stiffer in Z for the same amount of material and simplify sensor mounting and cabling.



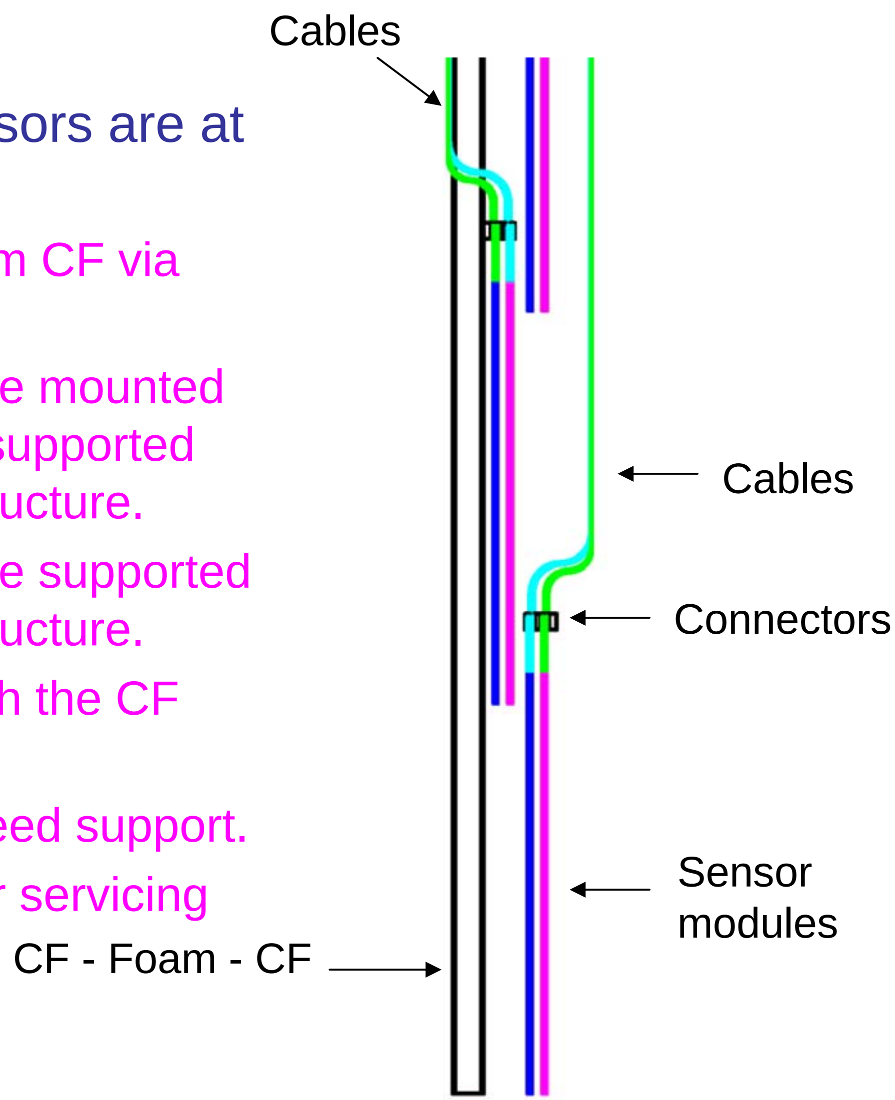
Sensor / Cable Arrangements

- No doubt there are other possible arrangements, but I've thought of three+:
  - Flat disks, alternating cable paths
  - Conical disks, cables toward IR
  - Conical disks, cables away from IR.
- Three more options with silicon on the CF surface which faces the IP
  - Less PR value, less access to silicon, but better silicon protection
- Conical disks allow a thinner support structure than do flat disks.
  - For convenience, all support structures are shown with a thickness = 7.275 mm.



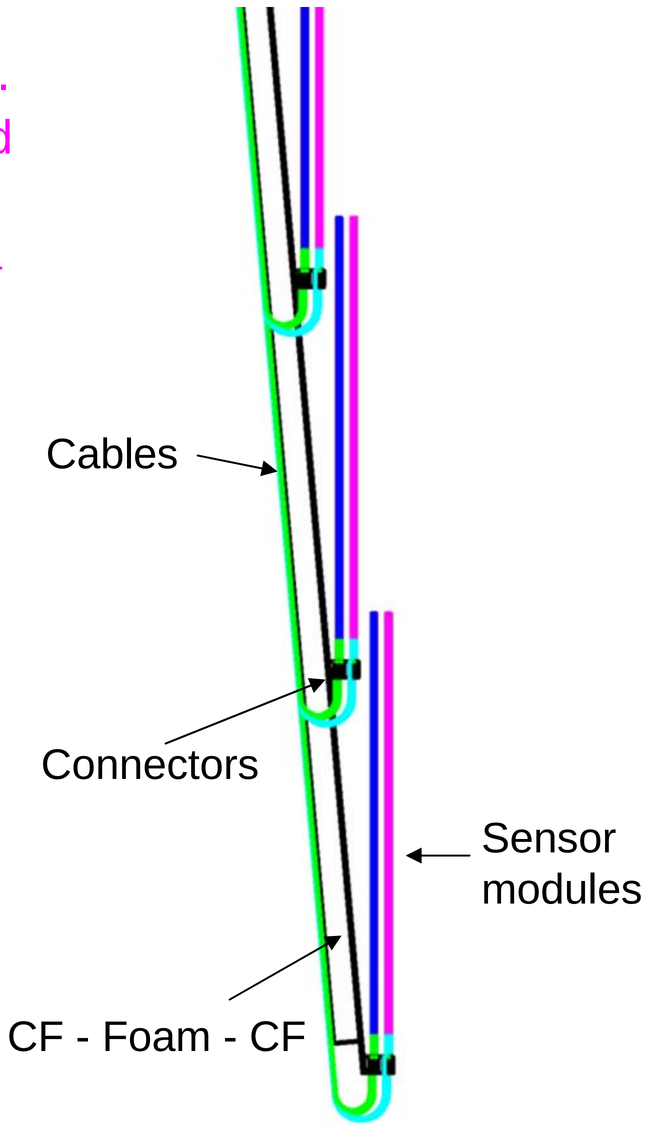
Sensor / Cable Arrangements

- Flat disks, alternating cable paths
- Reminder: blue and magenta sensors are at different sets of azimuths
  - All sensors could be mounted from CF via spacers.
  - Layer 1 and 2 connectors could be mounted from CF via spacers or could be supported from extensions of the module structure.
  - Layer 3 and 4 connectors could be supported from extensions of the module structure.
  - Half of cables are dressed through the CF support structure.
  - Half the cables are not and will need support.
  - These cables also limit access for servicing sensor modules.



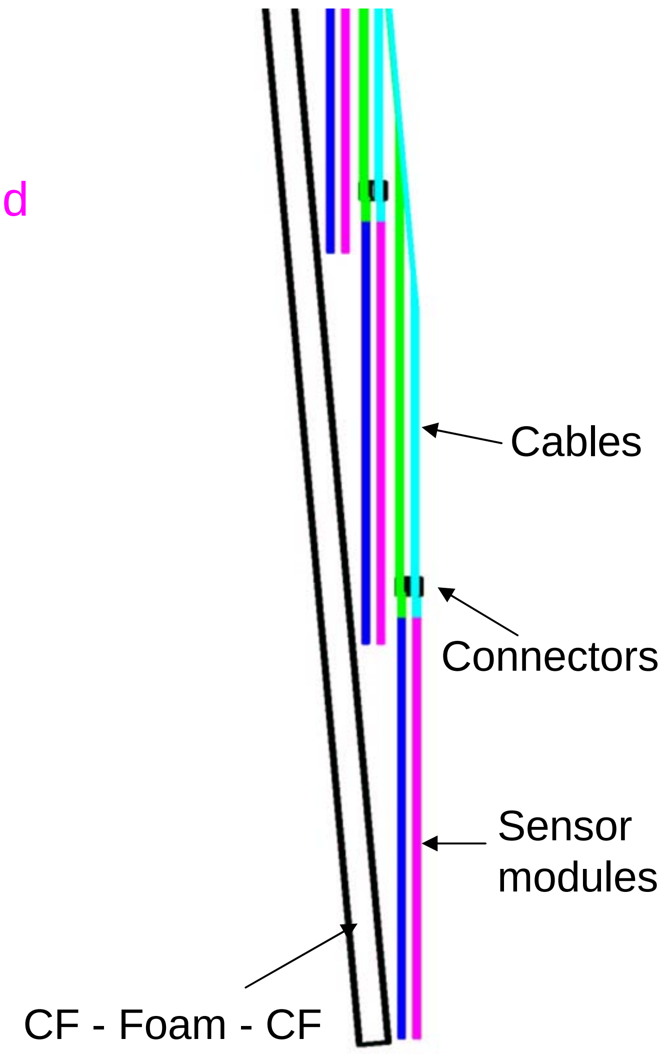
Sensor / Cable Arrangements

- Conical disks, cables toward IR
  - All sensors could be mounted via connectors.
  - Additional locating features for modules could be provided.
  - All connectors could be mounted from CF via short spacers.
  - All cables are dressed through the CF support structure.
  - Cable support is straight-forward.
  - Radial overlap covers connectors, so module servicing is done working from small to large radius.
  - Connectors and cable paths at the smallest radius take radial space.
- This is the arrangement we agreed to describe in the LOI, but with sensors on the CF surface facing the IP and connectors at the larger radius edge of each sensor.



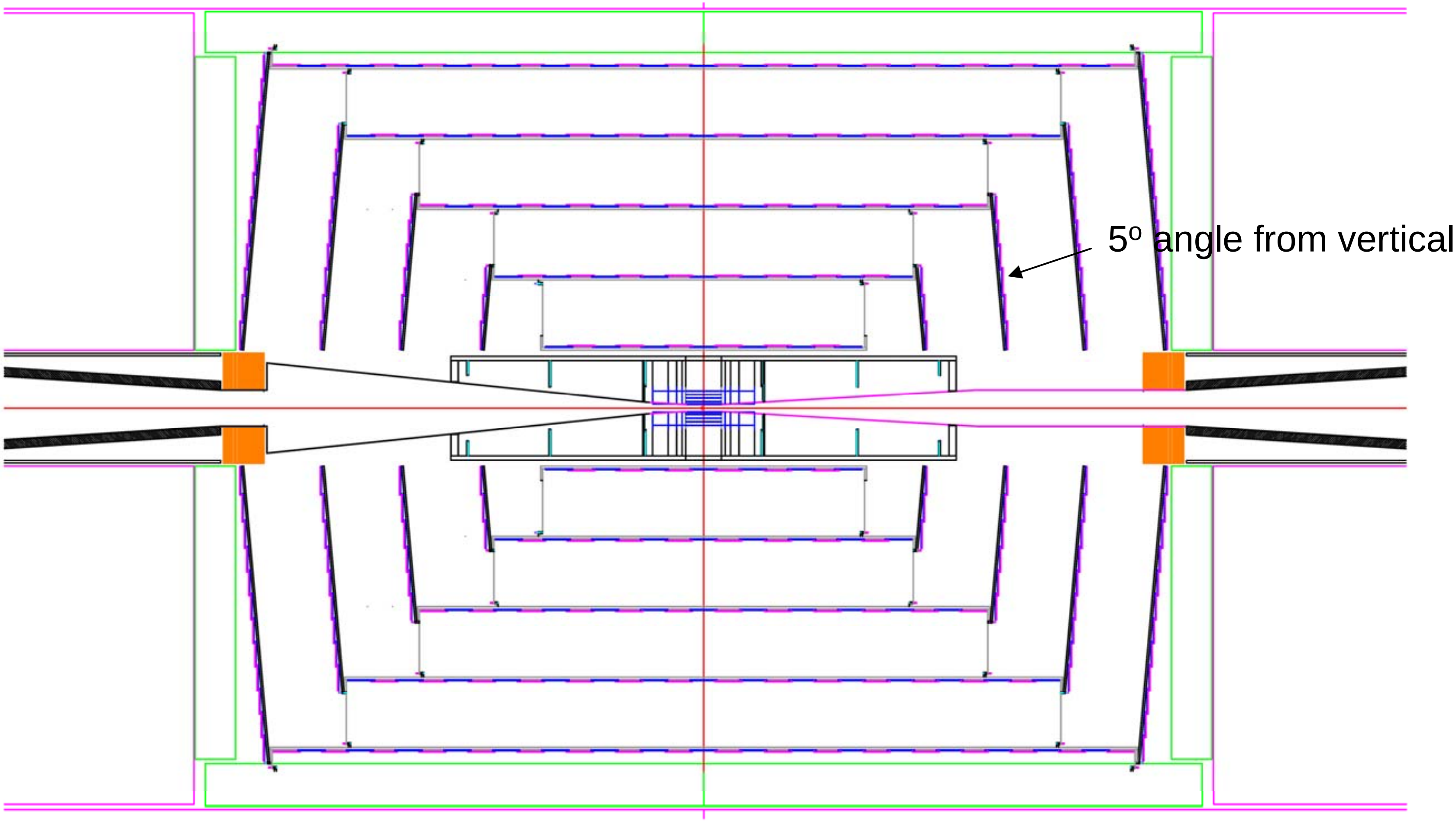
Sensor / Cable Arrangements

- Conical disks, cables away from IR
  - All sensors could be mounted from CF surface.
  - Additional locating features for modules could be provided.
  - All connectors could be mounted from extensions of the module structure, in which case, modules support the connectors.
  - All cables run across sensor surfaces and limit access during servicing.
  - Connectors are readily accessible, except to the extent cables cover them.
  - Connectors at the largest radius must be placed to avoid disk mounts (or vice versa).



Side elevation

- Based upon 8/13/08 detector geometry from Marco Oriunno



- Note that the Lumi-Cal's protrude into the silicon region and that two different beam pipe geometries are shown.

Comments

- For the LOI, we will avoid commenting on the potential for scattering from the LumiCal plates into the last disk.
  - Longer term, we need to understand whether this is a significant issue.
  - This feature may disappear when future adjustments to the overall detector length are made.
- So far, the forward calorimetry group favors a change to the beam pipe shown at the left, with its added conical section.
  - The Z-extent of the stainless steel portion of the cone will need to be checked for scattering into LumiCal and the outer tracker disks.

Sensor Overlaps

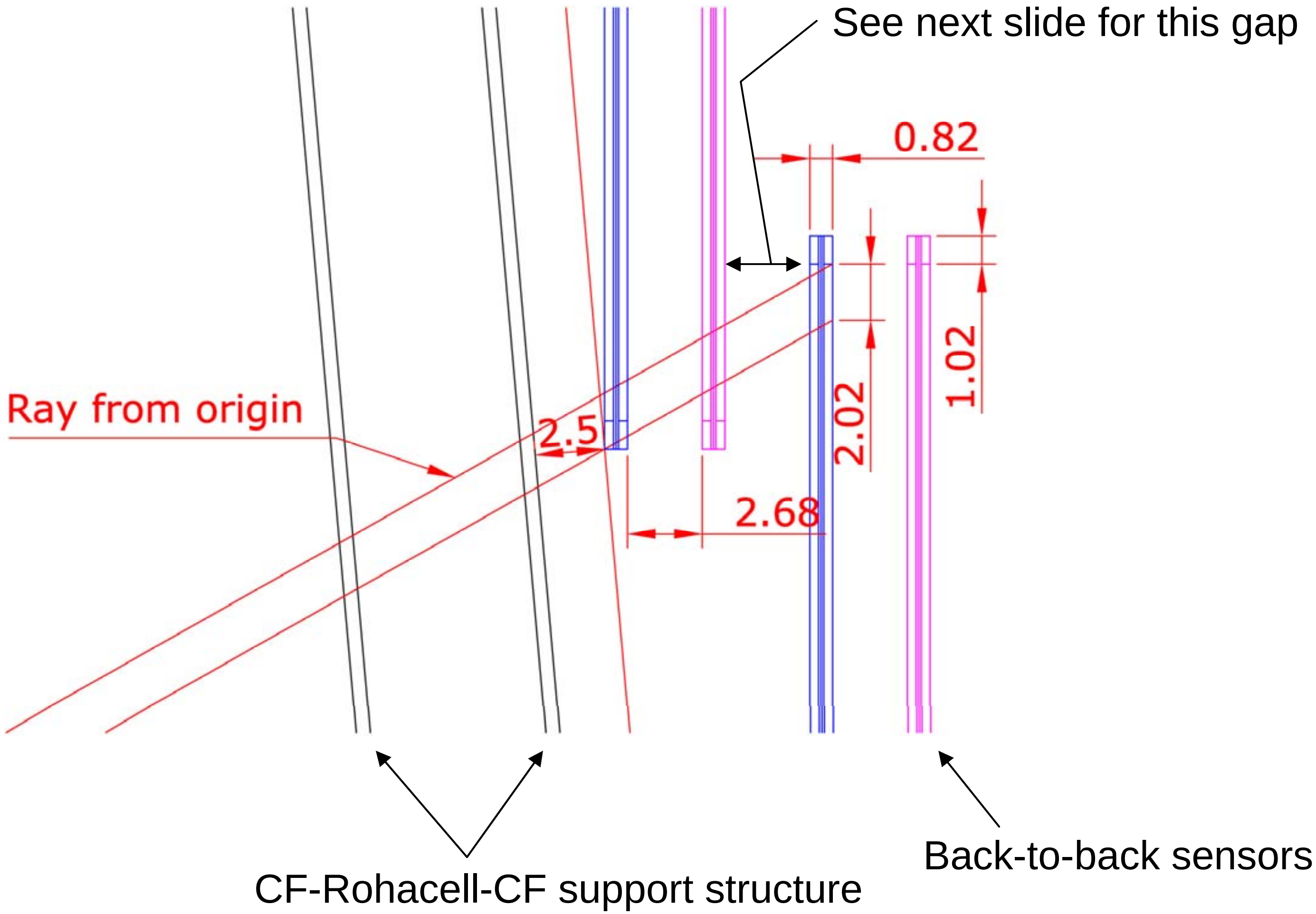
- We unanimously agreed that an arrangement with disk sensors in a single plane “butted” against one another would be undesirable.
  - ~ 6% dead area per sensor would apply to tracks independent of track momenta.
- On the other hand, overlapping sensors, if done properly, give 0 dead area for tracks that are nearly straight.
  - For tracks in which the helical path deviates significantly from a straight line, z-separation between adjoining sensors introduces gaps in coverage.
  - As in the barrels and vertex detector, we need to choose how hermetic the tracker should be for low momentum tracks.

Sensor Overlaps

- Initial cone design
  - We have assumed minimum phi overlap should equal the z-separation between central planes of adjacent modules (3.5 mm).
  - Minimum overlap in r has been taken to be 1 mm for straight tracks from the origin.
  - The result for hexagonal sensors is an overlap area of ~ 24%, i.e., sensor active area / cone area = 1.24.
  - Since support structures represent ~ ½ the material and sensors the other half, this effect on the material budget is halved.

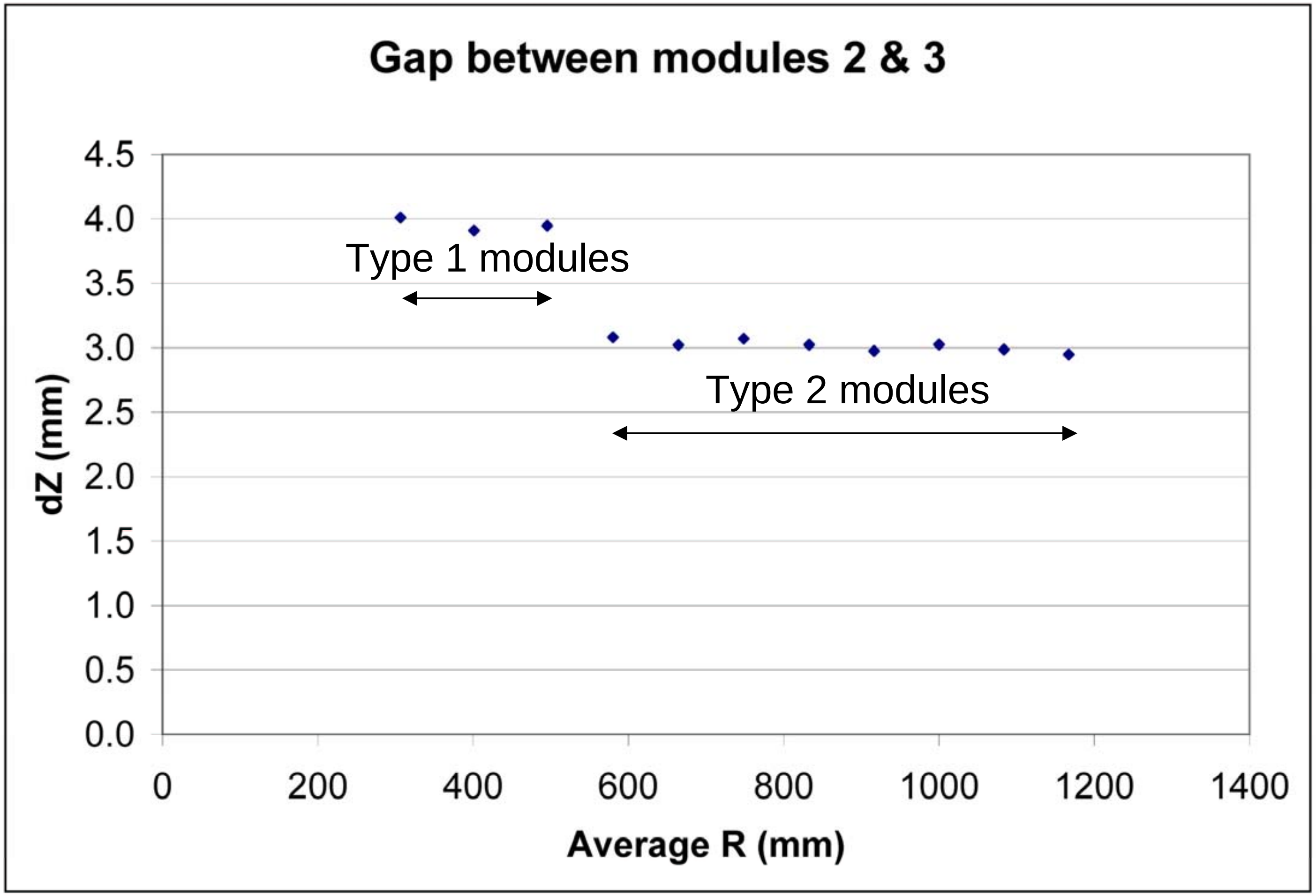
Parameters for R-overlaps

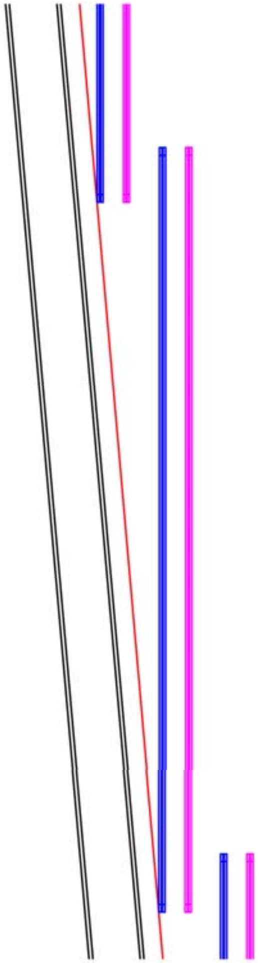
- Please note that blue modules are at one set of phi's, magenta modules at another.



Module-to-module gap

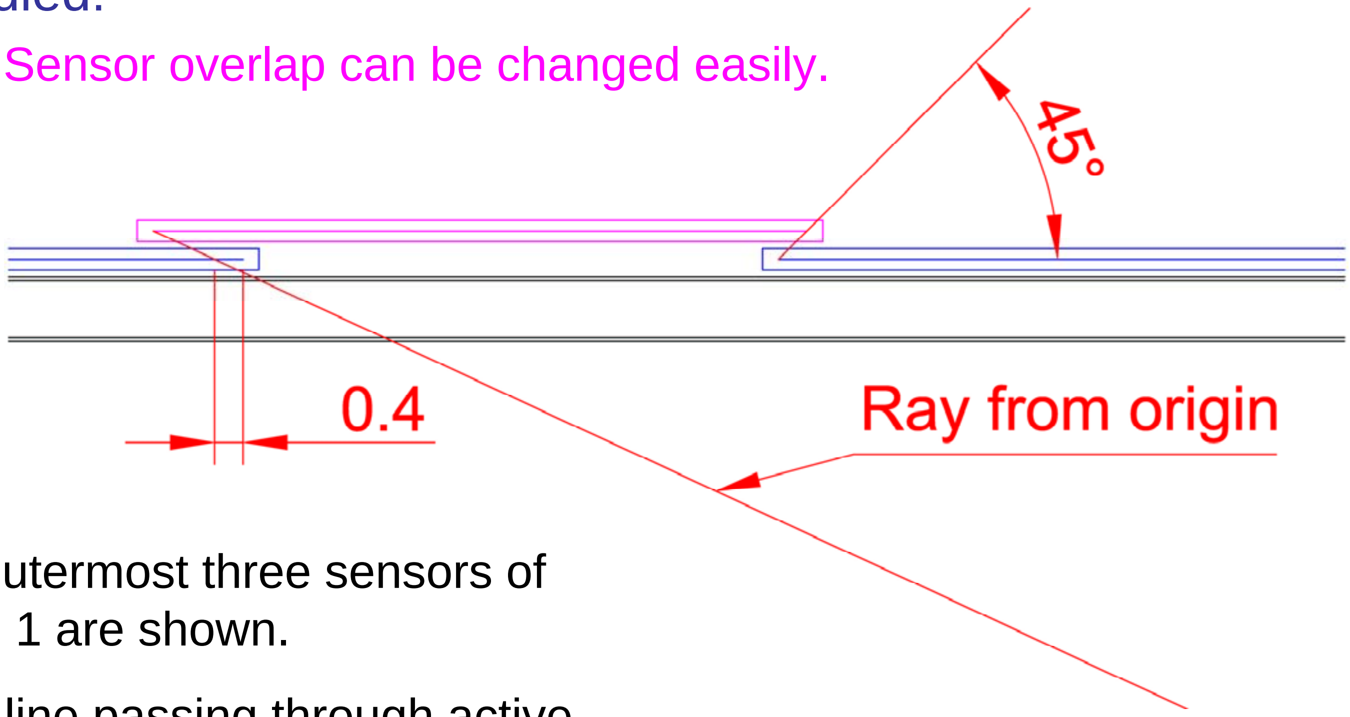
- Z-gap between modules 2 &3 depends primarily on the module height (dR_module), and to a lesser extent on incidence angle.





Outer Tracker Barrel: R-Z View

- Tracker review: Beijing 2007
- Typical A-layer to B-layer overlaps (all layers)
- Hermeticity for separated vertices versus material remains to be studied:
  - Sensor overlap can be changed easily.

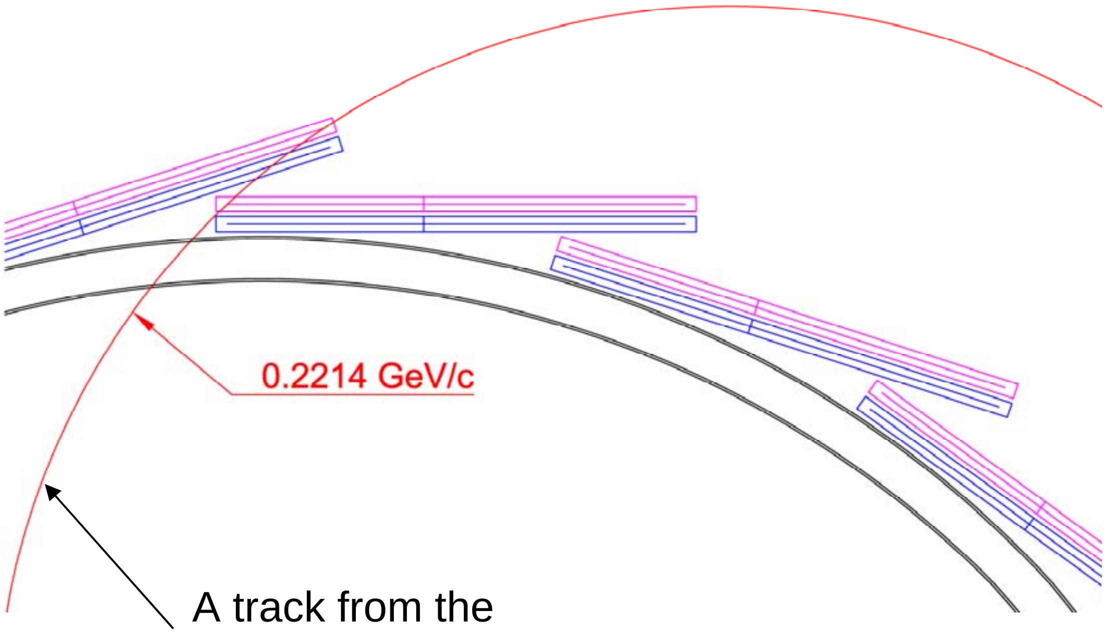


The outermost three sensors of barrel 1 are shown.

For a line passing through active edges of the left two sensors, DCA to origin = 6.7 cm (worst case).

Outer Tracker Barrel: R-Phi View

Barrel 1 is shown.



A track from the origin is shown (unit charge, 5 T field).

What momentum cut-offs do we really want?

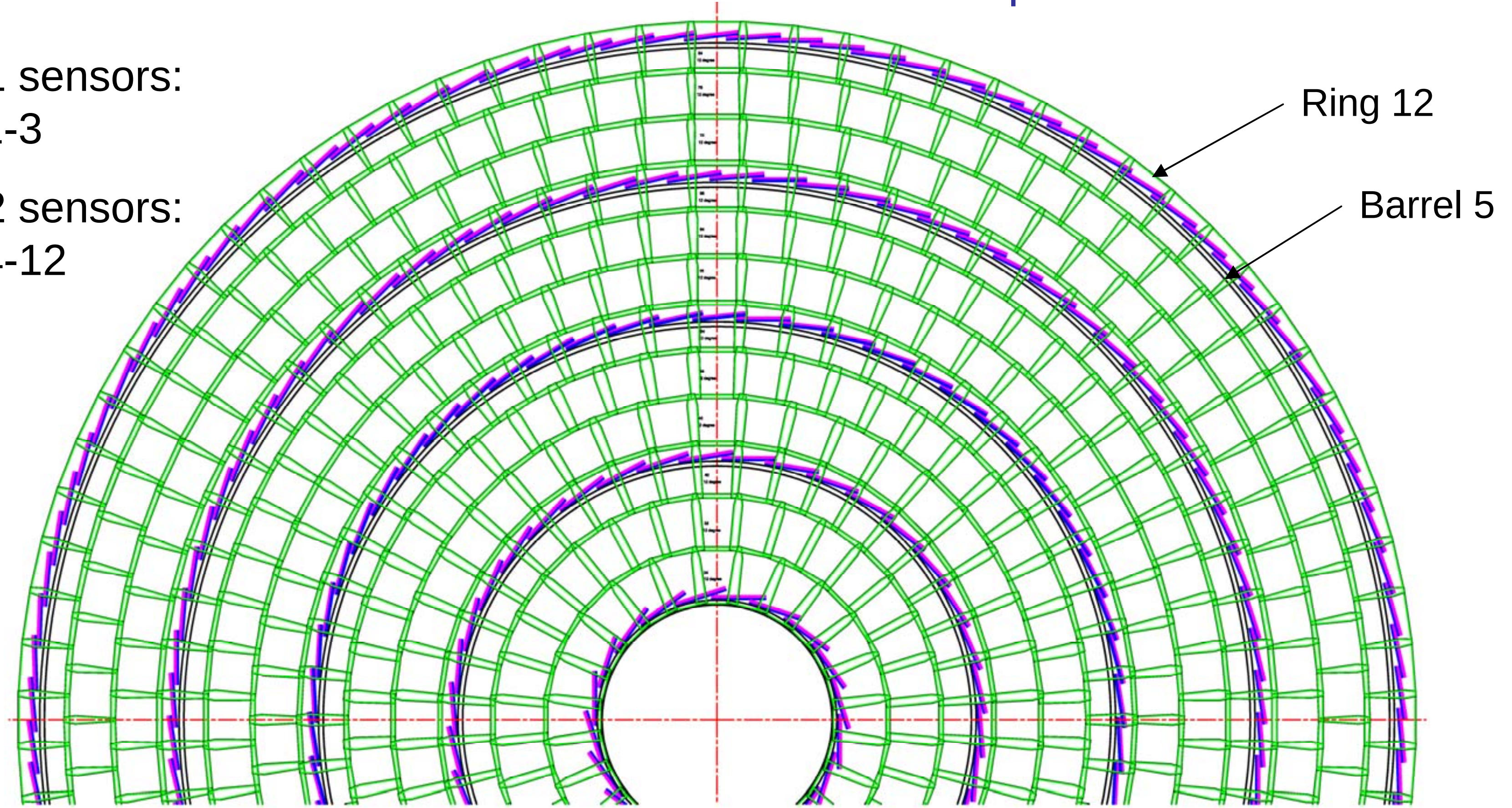
- With a pinwheel geometry, R-Phi coverage for one charge polarity is essentially hermetic.
- For the other polarity, a small fraction of low P_T tracks can pass between sensors.
- Studies will be needed to understand these small effects and the trade-offs between hermeticity and added material.

Disk Geometry in R-Phi

- Disk 4 with two types of sensors is shown.
  - Increasing the number of varieties would allow phi overlaps to be reduced.
- Relevant sensors in disks 1-3 have the same r-phi locations.

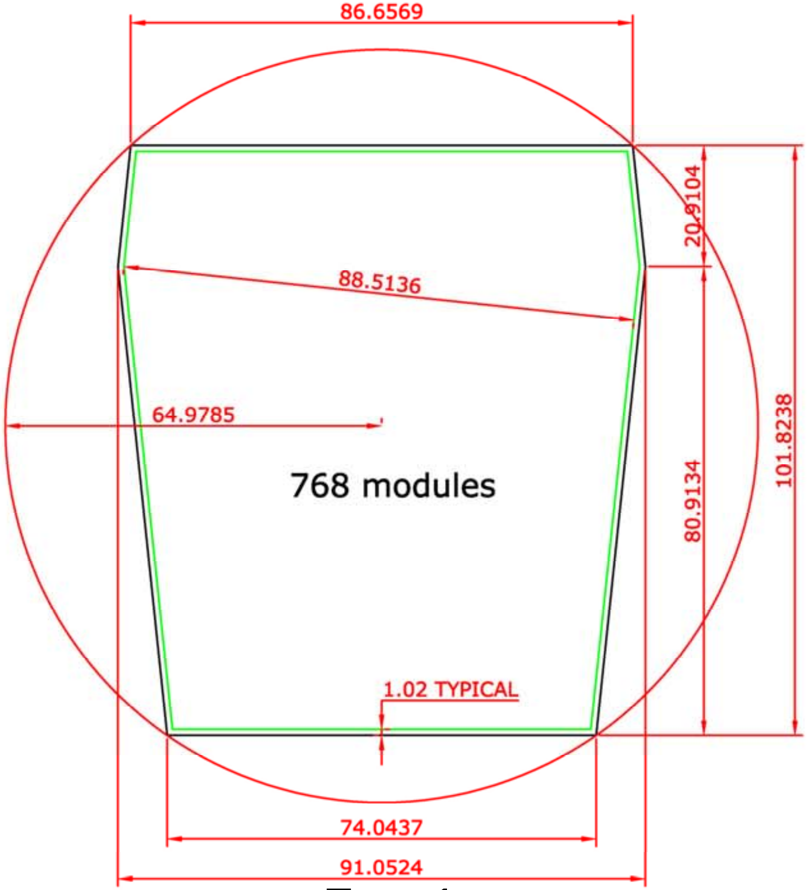
Type 1 sensors: rings 1-3

Type 2 sensors: rings 4-12

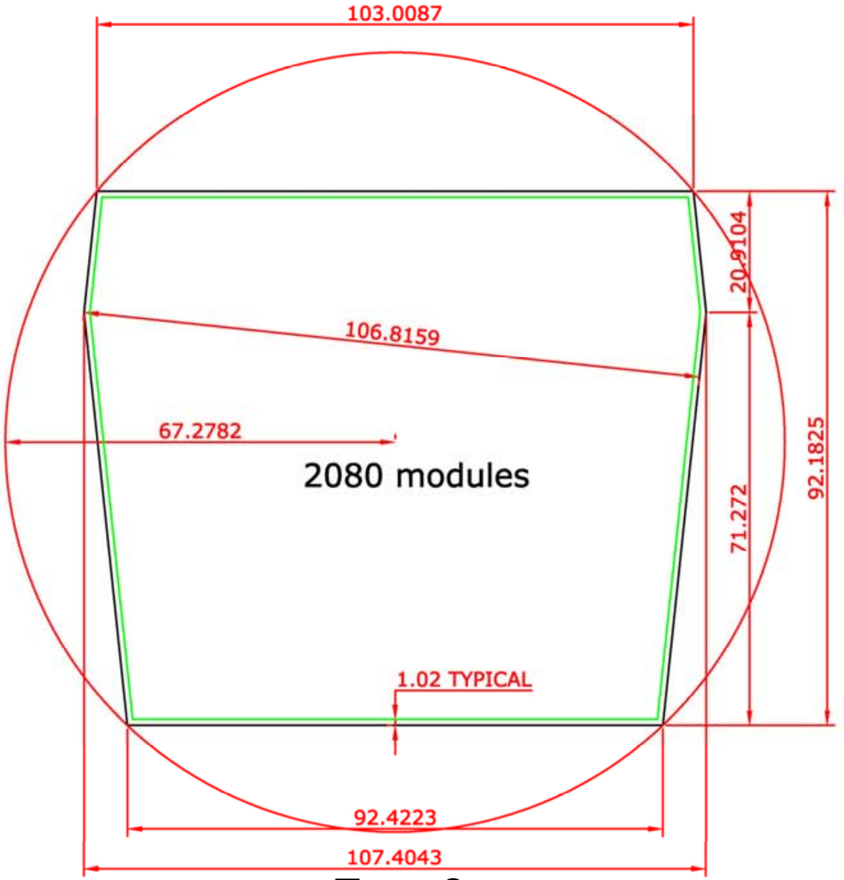


Sensors

- Two types of sensors are shown for 12º stereo: cut area in black, active area in green.
- The sensor to the right is a rather tight a fit on a 6” wafer.



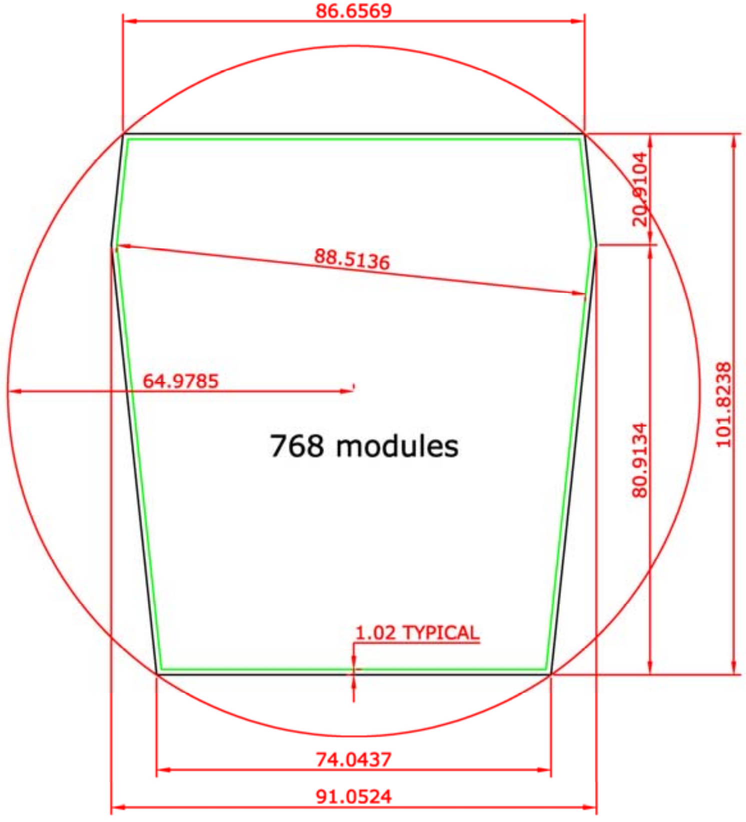
Type 1



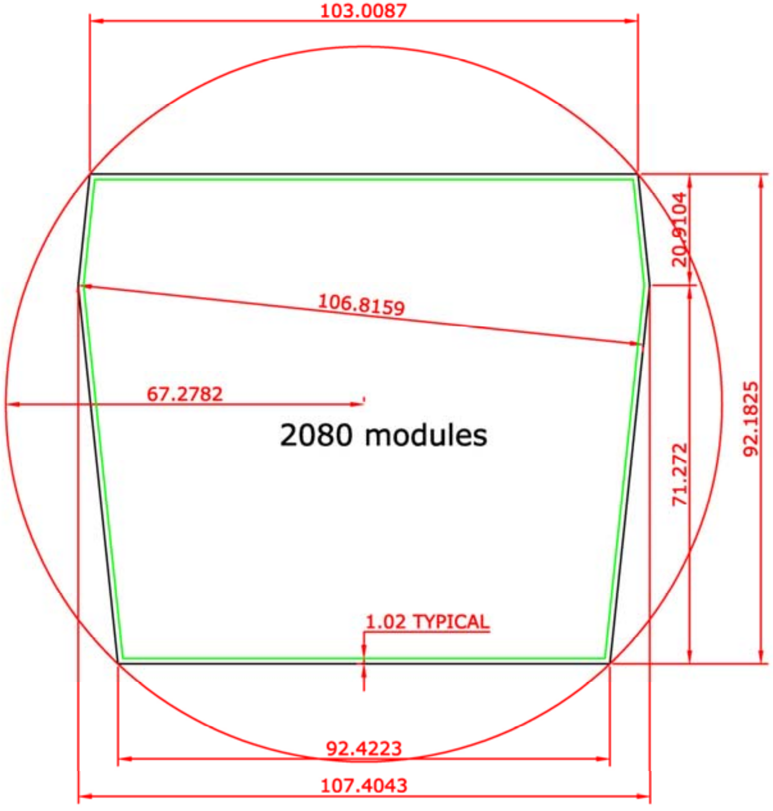
Type 2

Sensors

- Assuming traces run parallel to right long edges, the hexagonal shape ensures a shortest trace length of 20 mm.
  – If that were not necessary, phi overlaps could be reduced.
  – Other choices of method to obtain stereo generally double the number of sensor varieties (assuming sensors are not double-sided).



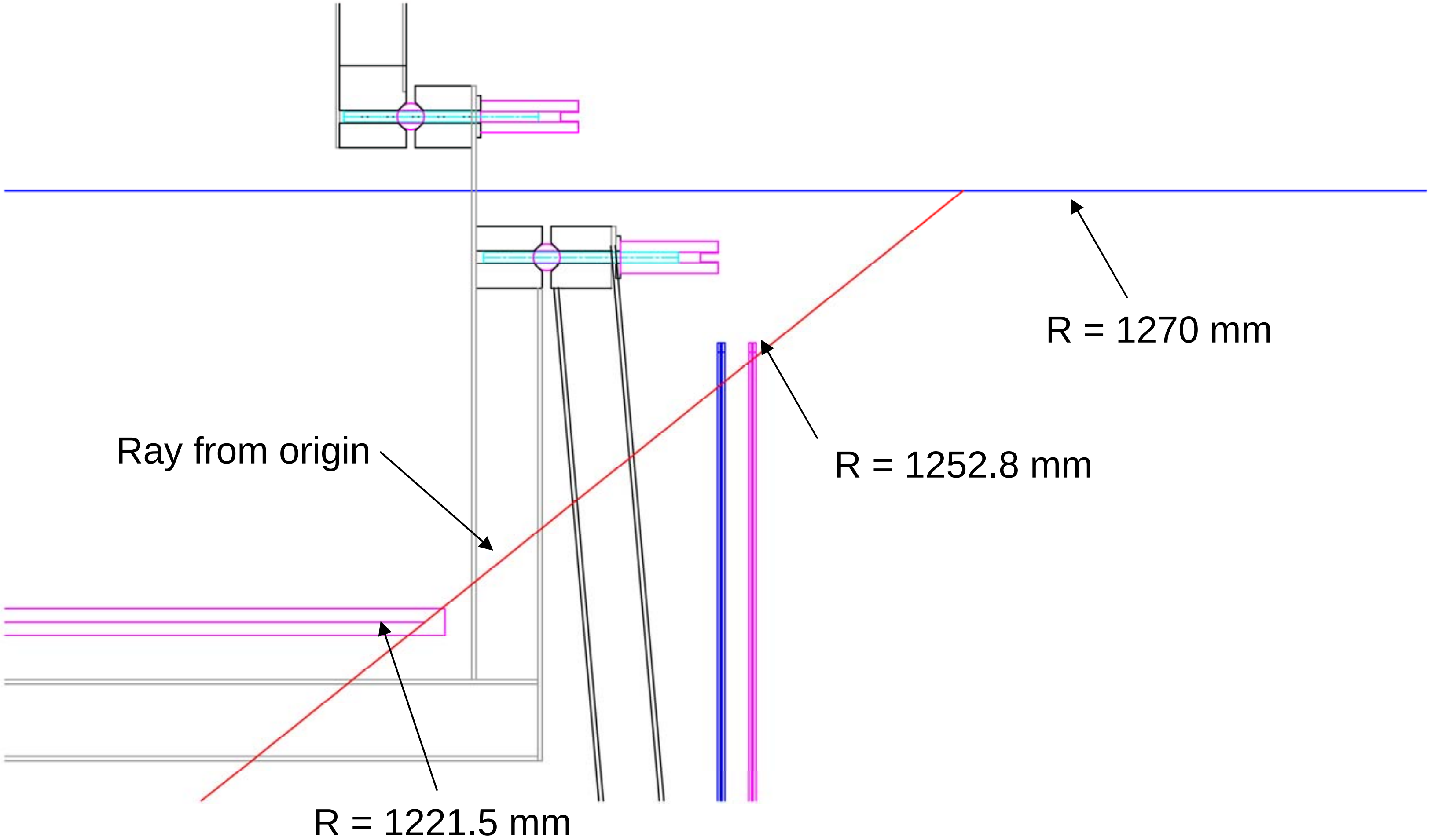
Type 1



Type 2

Disk-Barrel Overlap

- Obtaining adequate overlap leads to a larger disk radius than that of the associated barrel (a known “feature”).



Disk Modules

- To be developed
- Minimal structure
  - Back-to-back sensors would be vacuum laminated.
  - Should remain flat enough
  - Artwork between sensors for backside connections
  - Artwork on outer sensor services for chip connections
  - Connector at the inner radius of each module
  - Cables run through openings in the CF-Rohacell-CF disk structure and are dressed along the CF surface which faces the interaction point.
  - Pins locate each module transversely and guide it into a zif connector.

Possible Connectors

KYOCERA ELCO | Products | Product Type | FPC/FFC Connectors Page 1 of 3

KYOCERA KYOCERA ELCO Global THE NEW VALUE FRONTIER

Home News Products About

Parts No./Product Type Search Series Search

→Japanese

Products > Product Type > FPC/FFC Connectors

FPC/FFC Connectors

pitch(mm): | 0.2 | 0.3 | 0.4 | 0.5 | 0.8 | 1.0 | 1.25 | See the cable connection diagram

FPC/FFC Product Search

Click a series No., the product specifications can be seen. Click a catalog drawing, the product drawing and the product drawing and the ordering code can be seen.

Environmental Correspondence

Products

Product Type

FPC/FFC Connectors

- 0.2mm pitch
- 0.3mm pitch
- 0.4mm pitch
- 0.5mm pitch
- 0.8mm pitch
- 1.0mm pitch
- 1.25mm pitch

Board to Board Connectors

Memory Card Connectors

Interface Connectors

Wire to Wire/Board Connectors

Card Edge Connectors

Back Plane Connectors

Automotive Connectors

Shunt Connectors

0.2 to 0.5mm

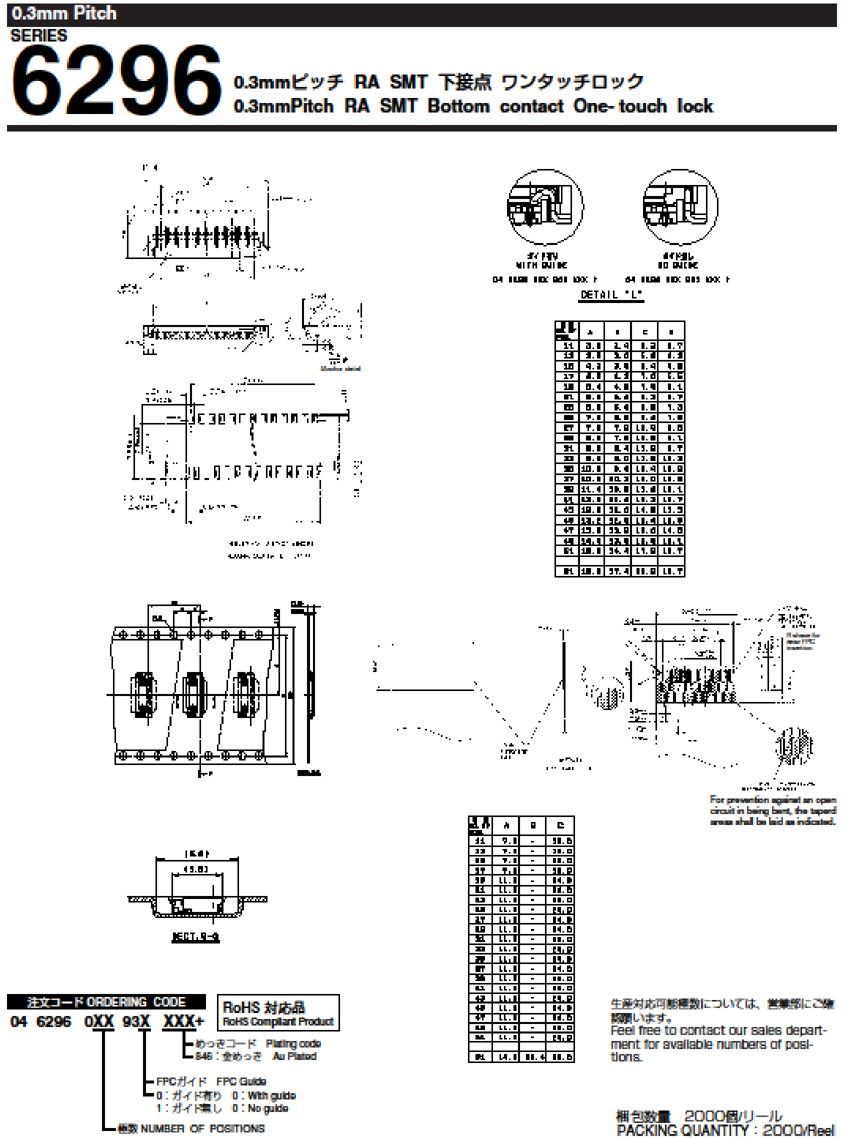
pitch: mm	Series	Profile Height (mm)	Cable connection See the connection diagram	Contact location	PC.Board mounting method	Rated Current (AC/DC) (Per one contact)	Catalog Drawing
0.2	6246	1.85	ZIF/Right Angle	Dual faced	SMT	0.2A	(208KB) PDF
0.3	6293	0.85	ZIF/Right Angle	Dual	SMT	0.2A	(203KB) PDF
	6840	0.9	ZIF/Right Angle	Bottom	SMT	0.2A	(153KB) PDF
	6295	0.9	ZIF/Right Angle	Bottom	SMT	0.2A	(139KB) PDF
	6296	1.0	ZIF/Right Angle	Bottom	SMT	0.2A	(143KB) PDF
	6283	1.1	ZIF/Right Angle	Top	SMT	0.2A	(119KB) PDF
	6285	1.1	ZIF/Right Angle	Bottom	SMT	0.2A	(171KB) PDF
	6281	1.25	ZIF/Right Angle	Bottom	SMT	0.2A	(150KB) PDF

Possible Connectors

A modern version of Hirose connectors.

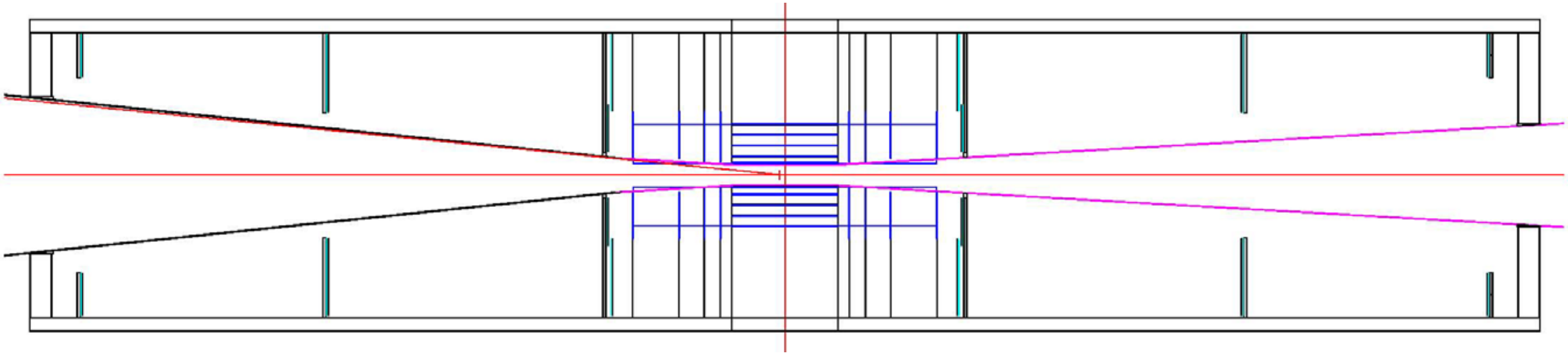
Improved latching mechanism.

These connectors appear to be designed for 0.2 mm thick cables (including a cable stiffener).



Vertex Detector

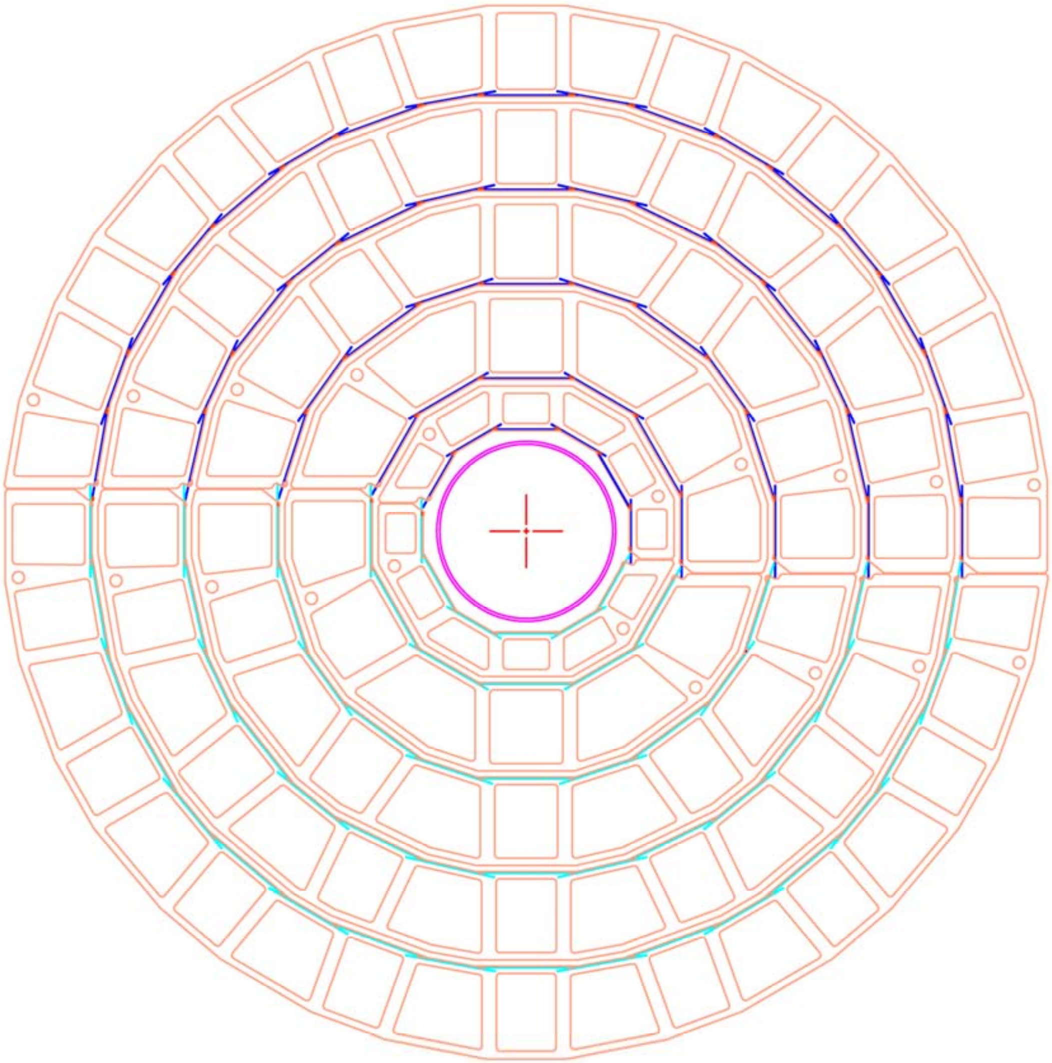
- The vertex detector to be described in the LOI is essentially unchanged with a few significant exceptions:
  - Pixel sensors will be used in the three “forward” disks at each end.
    - Formerly, we left open the option these would be microstrip sensors.
  - We need to reach agreement with MDI and FCAL groups on beam pipe geometry and adjust inner radii of the first 3 pixel disks accordingly.



Vertex Detector

- We propose to consider two types of structures for the vertex detector barrel (and possibly the disks):
- An “all-silicon” design (baseline)
  - In this context, all-silicon means that sensors serve as the structural components connecting one end of the barrel to the other.
  - Accommodation will be made in connections between barrel layers and from the barrel to the outer support structure to ensure that thermal contractions do not lead to significant forces or moments.
- Ladders in which silicon is supported from silicon-based-foam (primary alternative)
  - These minimize distortions associated with operation of sensors at a temperature significantly below room temperature, but require greater radial space.

All-silicon Barrel Layout



- Proposed to mitigate CTE issues

Sensor active widths:
L1: 8.6 mm
L2 - L5: 12.5 mm
Cut - active width: 0.08 mm
Inner radii:
A-layer: 14, 21, 34, 47, 60 mm
B-layer: 14.4593, 21.4965, 34.4510, 47.3944, 60.3546 mm
Sensors per layer:
12, 12, 20, 28, 36
Sensor-sensor gap: 0.1 mm
Sensor thickness: 0.075 mm
7 June 2007, 14 August 2007

- 75 µm silicon thickness assumed
- Could be modified for thicker or thinner sensors
- End rings dominate what you see.
- It should be straight-forward to ensure their out-of-round stiffness is large compared to that of sensors.
- End ring material has been assumed to be CF in initial modeling.

Comparison of Initial FEA Results – all silicon layer 5

Model boundary condition – simulating full model effect

10^{O} C delta T

	Gravity load only	Thermal displacement X	Thermal displacement Y	Thermal displacement Z
Case A	1.1 micron	4.0 microns	4.6 microns	3.95 micron
Case B	1.9 microns	4.6 microns	9.4 microns	4 microns
Colin's results *	1.4 microns	4.4 microns	8.1 microns	6.6 microns

Case A – runs using isotropic carbon fibre material properties;
Case B – model using orthotropic carbon fibre material properties compatible with those used by Colin;
Boundary condition used in Colin's model may be different from those used in Cases A & B – confirmation needed.

X direction – out-of-plane horizontal
Y direction – out-of-plane vertical;
Z direction -- axial

LCFI mechanical – S. Yang Oxford university